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CLAIMS

Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness consisting of: : 0.03 to 0.07 mass% С Si : not more than 0.6 mass% 5 : 1.5 to 2.5 mass% Mn : not more than 0.015 mass% Р : not more than 0.003 mass% S : 0.15 to 0.60 mass% ОМ : 0.01 to 0.10 mass% 10 Мb : 0.005 to 0.030 mass% Ti : not more than 0.10 mass% Al and, one or more of: : 0.1 to 1.5 mass% Ni : less than 3 ppm 15 В : not more than 0.10 mass% V : not more than 1.0 mass% Cu : not more than 1.0 mass% Cr : not more than 0.01 mass% Ca : not more than 0.02 mass% 20 REM : not more than 0.006 mass% Ma and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0, in which; the ratio (Hv-avep)/(Hv-M) between the average Vickers 25 hardness Hv-ave, in the direction of thickness and the martensitic hardness Hv-M determined by carbon content is between 0.8 and 0.9, and the transverse tensile strength TS-T_p is between 880 MPa and 1080 MPa, P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) +30 Mo - 1Hv-M = 270 + 1300Cwherein the symbols of elements designate the mass% of the individual elements. Steel plate for ultra-high-strength linepipe 35 having excellent low-temperature toughness consisting of:

: 0.03 to 0.07 mass%

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: not more than 0.6 mass%
           Si
                    .: 1.5 to 2.5 mass%
           Μn
                      : not more than 0.015 mass%
           Ρ
                     : not more than 0.003 mass%
           S
                     : 0.15 to 0.60 mass%
5
           Mo
                     : 0.01 to 0.10 mass%
           dN
                     : 0.005 to 0.030 mass%
           Tì
                      : not more than 0.10 mass%
           Al
                      : 3 ppm to 0.0025 mass%
           В
           and, one or more of:
10
                      : 0.1 to 1.5 mass%
           Νi
                      : 0.001 to 0.006 mass%
           N
                      : not more than 0.10 mass%
           V
                      : not more than 1.0 mass%
           Cu
                      : not more than 1.0 mass%
15
           Cr
                      : not more than 0.01 mass%
           Ca
                      : not more than 0.02 mass%
           REM
                      : not more than 0.006 mass%
           Μa
      and the remainder consisting of iron and unavoidable
      impurities and having the value P defined below being
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      between 2.5 and 4.0, in which;
      the ratio (Hv-ave_p)/(Hv-M) between the average Vickers
      hardness Hv-ave, in the direction of thickness and the
      martensitic hardness Hv-M determined by carbon content is
      between 0.8 and 0.9, and the transverse tensile strength
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P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + 2Mo

Hv-M = 270 + 1300C

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TS-Tp is between 880 MPa and 1080 MPa,

wherein the symbols of elements designate the mass% of the individual elements.

- 3. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in claim 1 or 2, containing:
- 35 N : 0.001 to 0.006 mass%.
 - 4. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in

claim 3, in which the relationship Ti - 3.4 N > 0 is satisfied (wherein the symbols of elements designate the mass% of the individual elements).

- 5. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 1 to 4, in which the V-notch Charpy value at -20 °C is not lower than 200J.
- 6. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 1 to 5, in which the longitudinal tensile strength $TS-L_p$ is not greater than 0.95 times the transverse tensile strength $TS-T_p$.
- 7. Steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 1 to 6, in which the yield ratio in the direction of rolling (YS L_p)/(TS L_p), which is the ratio of the 0.2% offset yield strength YS L_p in the direction of rolling to the tensile strength TS L_p in the direction of rolling is not greater than 0.8.
- 8. Ultra-high-strength linepipe having excellent low-temperature toughness prepared by seam-welding steel plate consisting of:

C : 0.03 to 0.07 mass%

Si : not more than 0.6 mass%

25 Mn : 1.5 to 2.5 mass%

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P : not more than 0.015 mass%

s : not more than 0.003 mass%

Ni : 0.1 to 1.5 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

Ti : 0.005 to 0.030 mass%

Al : not more than 0.06 mass%

and, one or more of:

B : not more than 0.0025 mass%

35 N : 0.001 to 0.006 mass%

V : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

REM : not more than 0.02 mass%

Mg : not more than 0.006 mass%

5 and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0, in which;

the ratio (Hv-ave)/(Hv-M) between the average Vickers hardness Hv-ave in the direction of thickness of the base metal and the martensitic hardness Hv-M determined by carbon content is between 0.8 and 0.9 and the circumferential tensile strength TS-C is between 900 MPa and 1100 MPa,

 $P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + (1 + \beta)Mo - 1+\beta$

where β = 1 when B \geq 3 ppm and β = 0 when B < 3 ppm Hv-M = 270 + 1300C

wherein the symbols of elements designate the mass% of the individual elements.

9. Ultra-high-strength linepipe having excellent low-temperature toughness prepared by seam-welding steel plate consisting of:

C : 0.03 to 0.07 mass%

Si : not more than 0.6 mass%

25 Mn : 1.5 to 2.5 mass%

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P : not more than 0.015 mass%

s : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

30 Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

B : less than 3 ppm

35 V : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

REM : not more than 0.02 mass%

Mg : not more than 0.006 mass%

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0, in which;

the ratio (Hv-ave)/(Hv-M*) between the average Vickers hardness Hv-ave in the direction of thickness of the base metal and the martensitic hardness Hv-M* determined by carbon content is between 0.75 and 0.9 and the circumferential tensile strength TS-C is between 900 MPa and 1100 MPa,

P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + Mo - 1

15 Hv-M* = 290 + 1300C

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wherein the symbols of elements designate the mass% of the individual elements.

10. Ultra-high-strength linepipe having excellent low-temperature toughness prepared by seam-welding steel plate consisting of:

c : 0.03 to 0.07 mass%

si : not more than 0.6 mass%

Mn : 1.5 to 2.5 mass%

P : not more than 0.015 mass%

25 s : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

30 B : 3 ppm to 0.0025 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

N : 0.001 to 0.006 mass%

v : not more than 0.10 mass%

35 Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

REM : not more than 0.02 mass%

Mg : not more than 0.006 mass%

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being

5 between 2.5 and 4.0, in which;

the ratio (Hv-ave)/(Hv-M*) between the average Vickers hardness Hv-ave in the direction of thickness of the base metal and the martensitic hardness Hv-M* determined by carbon content is between 0.75 and 0.9 and the

circumferential tensile strength TS-C is between 900 MPa and 1100 MPa,

P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + 2Mo

Hv-M* = 290 + 1300C

- wherein the symbols of elements designate the mass% of the individual elements.
 - 11. Ultra-high-strength linepipe having excellent low-temperature toughness described in claim 9 or 10 containing:

20 N : 0.001 to 0.006 mass%.

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- 12. Ultra-high-strength linepipe having excellent low-temperature toughness described in claim 11, in which the relationship ${\rm Ti}$ 3.4 N > 0 is satisfied (wherein the symbols of elements designate the mass% of the individual elements).
- 13. Ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 8 to 12, in which the V-notch Charpy value at -20 °C is not lower than 200J.
- 14. Ultra-high-strength linepipe having excellent low-temperature toughness described in any of claims 8 to 13, in which the tensile strength in the longitudinal direction of linepipe is not greater than 0.95 times the tensile strength in the circumferential direction thereof.
 - 15. A method for manufacturing steel plate for ultra-high-strength linepipe having excellent low-

temperature toughness comprising the steps of:

heating slabs consisting of:

C: 0.03 to 0.07 mass%

si : not more than 0.6 mass%

5 Mn : 1.5 to 2.5 mass%

P : not more than 0.015 mass%

s : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

10 Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

B : less than 3 ppm

15 v : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

REM : not more than 0.02 mass%

20 Mg : not more than 0.006 mass%

2.5

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and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0 and between 1000 and 1250 °C,

rough rolling in a recrystallizing region,

rolling in an unrecrystallization austenitic region at 900 °C or below with a cumulative rolling reduction of not less than 75% and, then,

applying accelerated cooling from the austenitic region so that the center of plate thickness cools to 500 °C or below at a rate of 1 to 10 °C/sec.,

$$P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + Mo - 1$$

wherein the symbols of elements designate the mass% of the individual elements.

35 16. A method for manufacturing steel plate for ultra-high-strength linepipe having excellent low-

temperature toughness comprising the steps of:

heating slabs consisting of:

C : 0.03 to 0.07 mass%

si : not more than 0.6 mass%

5 Mn : 1.5 to 2.5 mass%

P : not more than 0.015 mass%

s : not more than 0.003 mass%

Mo : 0.15 to 0.60 mass%

Nb : 0.01 to 0.10 mass%

10 Ti : 0.005 to 0.030 mass%

Al : not more than 0.10 mass%

B : 3 ppm to 0.0025 mass%

and, one or more of:

Ni : 0.1 to 1.5 mass%

15 N : 0.001 to 0.006 mass%

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v : not more than 0.10 mass%

Cu : not more than 1.0 mass%

Cr : not more than 1.0 mass%

Ca : not more than 0.01 mass%

20 REM : not more than 0.02 mass%

Mg : not more than 0.006 mass%

and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0 and between 1000 and 1250 °C,

25 rough rolling in a recrystallized region,

rolling in an unrecrystallization austenitic region at 900 °C or below with a cumulative rolling reduction of not less than 75% and, then,

applying accelerated cooling from the austenitic region so that the center of plate thickness cools to 500 °C or below at a rate of 1 to 10 °C/sec.,

$$P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + 2Mo$$

wherein the symbols of elements designate the mass% of the individual elements.

17. A method for manufacturing steel plate for

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ultra-high-strength linepipe having excellent low-temperature toughness described in claim 15 or 16, in which slabs also contain

N : 0.001 to 0.006 mass%.

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- 18. A method for manufacturing steel plate for ultra-high-strength linepipe having excellent low-temperature toughness described in 17, in which the relationship $\text{Ti} 3.4 \, \text{N} > 0$ is satisfied (wherein the symbols of elements designate the mass% of the individual elements).
- 19. A method for manufacturing ultra-high-strength linepipe having excellent low-temperature toughness comprising the steps of:

forming a steel plate manufactured by the methods for manufacturing ultra-high-strength steel plate having excellent low-temperature toughness described in any of claims 15 to 18 into a pipe form so that the rolling direction of the steel plate agrees with the longitudinal direction of a pipe to be manufactured, and

forming a pipe by seam-welding together the edges thereof.

20. A method for manufacturing ultra-high-strength linepipe having excellent low-temperature toughness comprising the steps of:

forming a steel plate manufactured by the methods for manufacturing ultra-high-strength steel plate having excellent low-temperature toughness described in any of claims 15 to 18 into a pipe form by the UO process so that the rolling direction of the steel plate agrees with the longitudinal direction of a pipe to be manufactured,

forming a pipe by joining together the edges thereof by applying submerged-arc welding from both inside and outside, and

expanding the welded pipe.

21. A method for manufacturing ultra-high-strength linepipe having excellent low-temperature toughness comprising the steps of:

heating slabs consisting of: : 0.03 to 0.07 mass% С : not more than 0.6 mass% Si : 1.5 to 2.5 mass% Μn : not more than 0.015 mass% 5 P : not more than 0.003 mass% S : 0.1 to 1.5 mass% Νi : 0.15 to 0.60 mass% Мо : 0.01 to 0.10 mass% Nb : 0.005 to 0.030 mass% Ti 10 : not more than 0.06 mass% Al and, one or more of: : not more than 0.0025 mass% В : 0.001 to 0.006 mass% N : not more than 0.10 mass% V 15 : not more than 1.0 mass% Cu : not more than 1.0 mass% Cr: not more than 0.01 mass% Ca : not more than 0.02 mass% REM : not more than 0.006 mass% 20 Mq and the remainder consisting of iron and unavoidable impurities and having the value P defined below being between 2.5 and 4.0 and between 1000 and 1250 °C, rough rolling in a recrystallized region, rolling in an unrecrystallization austenitic region 25 at 900 °C or below with a cumulative rolling reduction of not less than 75%, applying accelerated cooling from the austenitic region so that the center of plate thickness cools to 500 °C or below at a rate of 1 to 10 °C/sec., 30 forming the steel plate thus manufactured into a pipe form so that the rolling direction of the steel plate agrees with the longitudinal direction of a pipe to be manufactured, and forming a pipe by welding together the edges 35

thereof.

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$$P = 2.7C + 0.4Si + Mn + 0.8Cr + 0.45(Ni + Cu) + (1 + \beta) Mo - 1+\beta$$

where β = 1 when B \geq 3 ppm and β = 0 when B < 3 ppm wherein the symbols of elements designate the mass% of the individual elements.

22. A method for manufacturing ultra-high-strength linepipe having excellent low-temperature toughness described in claim 21, which furthermore comprising the steps of:

forming the steel plate subjected to accelerated cooling into a pipe form by the UO process so that the rolling direction of the steel plate agrees with the longitudinal direction of a pipe to be manufactured,

joining the edges thereof together by applying
submerged-arc welding from both inside and outside, and
expanding the welded pipe.